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Influence of organic manures on soil physical properties in cotton under rainfed conditions

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Abstract

Influence of organic manures on soil physical properties in cotton under rainfed Conditions in Vertisol[®] was conducted at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during *kharif* 2015-16. The experiment was laid out in RBD with ten treatments and three replications. Organic sources used were FYM, Vermicompost, Sun hemp, Castor cake, Neem cake and Sun hemp as in-situ green manure crop. The results indicated that after 6th year of organic cotton experimentation, significantly highest reduction in bulk density of soil (1.24 Mg m^{-3}) as well as significantly higher improvement in hydraulic conductivity 1.24 cm hr^{-1} of soil was reported by the treatment FYM @ 10 t ha⁻¹.

Keywords: Cotton, Rainfed, Organic, Bulk density, Hydraulic conductivity

1. Introduction

Organic cotton has been produced for centuries, but it was first officially certified in 1980-90 by Turkey, followed by USA. Other common names used for organic cotton, particularly at the beginning of production are green cotton, biological cotton and environment friendly cotton. The technical information section of International Cotton Advisory Committee has kept track of organic cotton production in world. It is assumed that production has not increased beyond the experimental stage in countries other than India, Turkey and the USA.

In India 2015-16, cotton is grown on 118.81 lakh ha with production of 352.00 lakh bales and yield 504 kg ha^{-1} . In Maharashtra, cotton is grown on 41.92 lakh ha with production 85 lakh bales and yield $345 \text{ kg lint ha}^{-1}$. Cotton is the most capital intensive cash crop grown predominantly in Maharashtra. It covers about 34 per cent of total cotton area and contributes 17 per cent of the production. About 97 per cent of the cotton crop is cultivated under rainfed condition. In Vidarbha region, area under cultivation of cotton is 12.37 lakh ha with production of about 35 lakh bales and $312 \text{ kg lint ha}^{-1}$.

Organic cotton production system use integrated nutrient management practices *viz.*, organic manures, cakes, green manures etc. and integrated organic plant protection *viz.*, agronomic practices, crop rotation, botanicals, bio-pesticides, apart from encouraging natural parasites, predators and parasitoids etc, in the environment. The use of organic manures has been the traditional means of maintaining soil fertility. The quality of the fibre may also be affected. Most organic manures provide a balanced source of nutrients for crops. Organic manures have a direct effect on plant growth like any other commercial fertilizer. Organic manures also contain traces of micro-nutrients and also provide food for soil microorganisms. This increases activity of microbes which in turn helps to convert unavailable plant nutrients into available and also fixing atmospheric nitrogen.

Farmyard manure provides essential plant nutrients including micronutrients and it also improves soil physical, chemical and biological environment of soil for favourable crop growth and yield. It is also known to accelerate the respiratory process that increase cell permeability and hormonal growth action or by combination of all these processes (Ismail *et al.* 1998) ^[6]. Farm Yard Manure (FYM) increases organic carbon content in the soil and improves soil physical properties

Similarly, vermicompost is an excellent source of nutrients for crops and helps to convert organic waste into rich humus (Anonymous, 1992) ^[1]. Vermicompost is a rich source of micro and macronutrient. The nutrients present in it are readily water soluble for the uptake of micro flora. Vermicompost, which is produced by earthworms, is a rich source of both micro and macro nutrients, vitamins, growth hormones and enzymes (Bhavalkar, 1991) ^[3].

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Green manuring is an age old concept of soil fertility management and being practiced to incorporate the succulent green portion of plants such as leaves, twigs and lopping of trees into soil. Green manuring crops are known to fix atmospheric nitrogen, improve soil structure and recycle the nutrients. Decomposition of organic manure resulting in liberation of CO₂ which influences on weathering of minerals and ultimate release of plant nutrient. Nutrient content in sun hemp (*Crotalaria juncea*) are 2.30 per cent N, 0.50 per cent P₂O₅ and 1.80 per cent K₂O on air-dry basis.

Scope of study

Cotton is most important fibre crop not only in India but of entire world. Cotton in India provides direct livelihood to 6 million farmers. Cotton cultivation consumed 44.5% of the total pesticides used in the country. The preamble of organic farming has been aimed at conservation and optimized utilization of all natural resources for a reasonable profitability under the guiding factor of sustainability of the agriculture. Constant increasing high cost of chemical fertilizers creating economic problems to the small and marginal farmers and on the other hand soils are becoming ill due to imbalance utilization of chemical fertilizers.

During last decade, it is quite satisfying to find that organic cultivation proved its way for increased adoption of non-chemical farming. In Maharashtra, particularly in Vidharbha region cotton productivity is low due to poor distribution of rainfall and low resource investment by farmers. Such soils required to external inputs production system to minimise cost on fertilizer and pesticides

for stability in production. Organic cotton cultivation methods have helped farmers to improve sustainable productivity and soil health.

Limitations

Nineteen countries tried to produce organic cotton during 1990s. But many of them have already stopped, not for lack of desire or demand for such cotton but for economic reasons. Some of the limitation subject to Indian condition is listed below.

1. Control of pests or insects without use of pesticides/insecticides.
2. Availability of the organic manures is FYM, oilcake and composts etc.
3. Cost of production of organic cotton versus conventional cotton.
4. Different organic cotton certification, companies have established their own organic cotton production standard and price premium on organic cotton is also one of the major issue.

2. Material and methods

The field investigation in relation to "Effect of rainfed cotton on soil physical properties in Vertisol" was conducted during *kharif* season of 2015-16 at Cotton Research Unit (CRU), Central Research Station (CRS) Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The details of material used and methods adopted during the period of experimentation are given below.

Experimental Site

The experimentation was superimposed on the ongoing organic cotton experiment at CRU on "Technology for organic cotton production" and this is the sixth year (6th cycle) of experiment. Before initiation of the experiment the

experimental plot was manured with common dose of FYM (5 t ha⁻¹) followed by in-situ green manuring of sun hemp and from the year 2010-11 the fixed frame plot experimentation with ten treatments (out of which one absolute control) was laid out with cotton as a test crop. (Most preferred rainfed cash crop, in the Vidharbha region.)

Soils of experimental area

The soils of the experimental area were medium deep black, clay loam texture with typical swell-shrink, deep cracks, high water holding capacity, dominant in Montmorillonite clay mineral and slickensides characteristics classified under order Vertisol.

Table 1: Treatments Details

S. No.	Treatment
1	T ₁ - FYM @ 5 t ha ⁻¹
2	T ₂ - Vermicompost @ 2.5 t ha ⁻¹
3	T ₃ - FYM @ 10 t ha ⁻¹
4	T ₄ - Vermicompost @ 5 t ha ⁻¹
5	T ₅ - In-situ green manuring with sunhemp
6	T ₆ - Castor cake @ 500 kg ha ⁻¹
7	T ₇ - FYM (source of 15 kg P ₂ O ₅) + green manuring with sunhemp
8	T ₈ - Neem cake @ 500 kg ha ⁻¹
9	T ₉ - FYM 5 t ha ⁻¹ + Neem cake @ 500 kg ha ⁻¹
10	T ₁₀ - Absolute Control

Note: Common seed treatment of Azotobacter and PSB @ 25 g kg⁻¹ seed to all treatments except Absolute control i.e. T₁₀ treatment.

Application of organic manures

Five organic sources of nutrients were used for the "Organic cotton experimentation" out of which two viz., FYM and vermicompost were well decomposed bulky organic manures and castor cake and neem cake were concentrate organic manures and sunhemp was used for in-situ green manuring. The major nutrient content estimated before their incorporation to the field and its treatment wise addition of nutrient (NPK) are given in Table 2 and Table 3.

Table 2: Nutrient content (%) in organic sources used for the experimentation

Organic sources	N	P	K
FYM	0.44	0.19	0.68
Vermicompost	1.23	1.49	0.60
Castor cake	5.15	1.46	1.24
Neem cake	5.32	1.07	1.42
Sunhemp (Oven dry basis)	1.28	0.24	2.18

Table 3: Addition of nutrients from various sources (kg ha⁻¹)

S. No	Addition of nutrients	N	P	K
1	2.5 t Vermicompost	30.5	37.5	15
2	5 t FYM	21.5	9.25	34
3	5 t Vermicompost	61	75	30
4	10 t FYM	43	18.5	68
5	500 kg Castor cake	25.25	7.5	6.2
6	500 kg Neem cake	26.5	5.35	7.2
7	In-situ Green manuring of sunhemp at 45 DAS	27	5.1	46

The sunhemp crop was raised between the rows of cotton crop which was buried in situ 45 DAS as a green manuring treatment. All the cultural and plant protection measures were adopted as and when required.

The data obtained various parameters were analysed in RBD statistical procedure (Panse and Sukhatme, 1984). The

appropriate standard error of mean (S.E.m) and the critical difference (C.D.) were calculated at 5% level of probability

3. Results and discussion

Influence of organic sources on Bulk density and Hydraulic conductivity in Vertisols under cotton cultivation.

The effect of various organic sources nutrient management on soil physical properties after harvest of the cotton crop viz. Bulk density and hydraulic conductivity were studied and results obtained from experimentation are presented and discussed below. In general bulky organic manures have more effects on soil physical properties as compared to concentrated organic manures under study.

1. Bulk density

The data regarding bulk density of soil is presented in Table 4 and depicted in Fig. 1(a) under different organic treatments and it was ranged from 1.24 to 1.34 Mg m⁻³. Significant influence on bulk density of soils was observed under different organic sources over control.

As the doses of well decompose organic sources i.e. FYM and vermicompost increased there was reduction in bulk density of the soil. However, use of neem cake in combination with FYM reported slightly increased in bulk density over well decomposed treatment but was at par to each other.

Significantly lowest bulk density 1.24 Mg m⁻³ was recorded by the treatment received FYM @ 10 t ha⁻¹ and it was at par with all other organic treatments. The highest 1.34 Mg m⁻³ bulk density in Vertisol was observed in absolute control treatment. In general treatments comprising with bulky organic manures was recorded lower values of bulk density over concentrated organic manures and in-situ green manuring.

Significant reduction in bulk density with the application of FYM @ 10 t ha⁻¹ over control treatment was also reported by Katkar *et al.* (2007) [7]. Similar results regarding significant reduction in bulk density of Vertisols with incorporation of sunhemp and FYM over control treatment was also reported by Bellakki and Badanur (1997) [2], Surekha and Rao (2009) [12] and Vora *et al.* (2015) [13].

From the experiment it can be evident that incorporation of organic manures helps to reduce the soil weight due to proper maintenance of soil: moisture: air ratio, which ultimately

reflected on reduction in bulk density of the Vertisols. The improvement in bulk density of soil is directly proportional to the increasing doses of the organic manure. Continuous application of FYM @ 10 t ha⁻¹ may lead to higher aggregation of soil particles followed by vermicompost @ 5 t ha⁻¹ over control treatment was also reported by Marathe and Bharambe, (2005) [9]. Whereas, Laharia *et al.* (2013) [8] observed minimum bulk density of soil with application of 100% RDN through vermicompost + jeevamrut.

Table 4: Effect of organic sources on BD and HC in Vertisols under cotton

Treatment	Physical properties	
	Bulk density (Mg m ⁻³)	Hydraulic conductivity (cm hr ⁻¹)
T ₁ -FYM @ 5 t ha ⁻¹	1.25	1.07
T ₂ -Vermicompost @ 2.5 t ha ⁻¹	1.27	1.02
T ₃ -FYM @ 10 t ha ⁻¹	1.24	1.24
T ₄ -Vermicompost @ 5 t ha ⁻¹	1.25	1.09
T ₅ -Insitu green manuring with sunhemp	1.26	1.11
T ₆ -Castor cake @ 500 kg ha ⁻¹	1.26	1.01
T ₇ -FYM (source of 15 kg P ₂ O ₅) + green manuring with sunhemp	1.25	1.17
T ₈ -Neem cake @ 500 kg ha ⁻¹	1.28	1.01
T ₉ . FYM(5t ha ⁻¹)+Neem cake@500 kg ha ⁻¹	1.26	1.03
T ₁₀ -Absolute Control	1.34	0.75
SE (m) ±	0.014	0.070
CD at 5%	0.044	0.209

2. Hydraulic conductivity

Data regarding the saturated hydraulic conductivity of experimental soil after harvest of crop is given in Table 4 and Fig. 1(b). Hydraulic conductivity of the soil was statistically significant under different organic treatments over control and ranged from 0.75 to 1.24 cm hr⁻¹.

The data regarding hydraulic conductivity of the soil revealed that, incorporation of organic manures as a source of plant nutrient improved the drainability in Vertisols.

Data revealed that, the significantly highest value (1.24 cm hr⁻¹) of hydraulic conductivity was recorded by treatment received FYM @

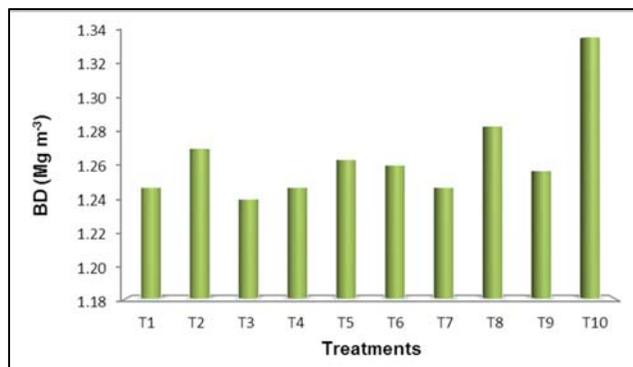


Fig 1(a): Effect of organic sources on bulk density of Vertisols under cotton

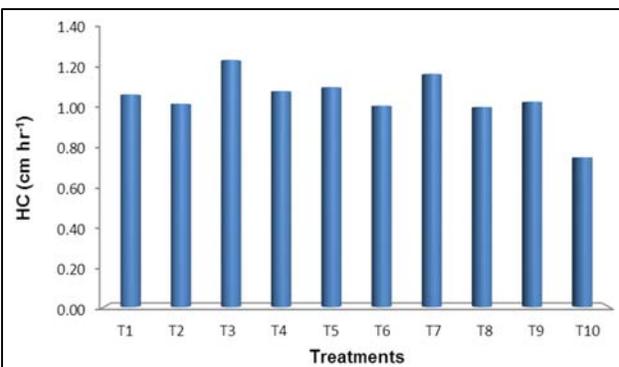


Fig 1(b): Effect of organic sources on Hydraulic Conductivity of Vertisols under cotton

10 t ha⁻¹ and it was at par with FYM + green manuring with sunhemp (T₇), Insitu green manuring with sunhemp (T₅), Vermicompost @ 5 t ha⁻¹ (T₄), FYM @ 5 t ha⁻¹ (T₁) and FYM + Neem cake@500 kg ha⁻¹ (T₉). The lowest hydraulic

conductivity was observed under absolute control (T₁₀). Among all treatments applied with bulky organic manures showed higher hydraulic conductivity over concentrated organic manures and in-situ green manuring treatments.

Similar findings were observed by Marathe and Bharmbe (2005) ^[9], Selvi *et al.* (2005) ^[11] and Chalwade *et al.* (2006) ^[4] stated that, significant increase in hydraulic conductivity in Vertisols with application of organic sources over control. Gayatri *et al.* (2010) ^[5] studied long term experiment and reported that, better aggregation and increased porosity as a consequence of the addition of organics have a favourable influence on soil physical properties like hydraulic conductivity which influences the soil water dynamics.

4. Conclusions

Impact of organic sources on physical properties revealed that, indicated that after 6th year of organic cotton experimentation, significantly highest reduction in bulk density of soil (1.24 Mg m⁻³) as well as significantly higher improvement in hydraulic conductivity 1.24 cm hr⁻¹ of soil was reported by the treatment FYM @ 10 t ha⁻¹.

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